

Total Cost Comparison of 2 Biopsy Methods for Nonpalpable Breast Lesions

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Objective: To identify, quantify, and compare total facility costs for 2 breast biopsy methods: vacuum-assisted biopsy (VAB) and needle-wire-localized open surgical biopsy (OSB).

Study Design: A time-and-motion study was done to identify unit resources used in both procedures. Costs were imputed from published literature to value resources. A comparison of the total (fixed and variable) costs of the 2 procedures was done.

Patients and Method: A convenience sample of 2 high-volume breast biopsy (both VAB and OSB) facilities was identified. A third facility (OSB only) and 8 other sites (VAB only) were used to capture variation. Staff interviews, patient medical records, and billing data were used to check observed data. One hundred and sixty-seven uncomplicated procedures (71 OSBs, 96 VABs) were observed. Available demographic and clinical data were analyzed to assess selection bias, and sensitivity analyses were done on the main assumptions.

Results: The total facility costs of the VAB procedure were lower than the costs of the OSB procedure. The overall cost advantage for using VAB ranges from \$314 to \$843 per procedure depending on the facility type. Variable cost comparison indicated little difference between the 2 procedures. The largest fixed cost difference was \$763.

Conclusions: Facilities must consider the cost of new technology, especially when the new technology is as effective as the present technology. The seemingly high cost of equipment might negatively influence a decision to adopt VAB, but when total facility costs were analyzed, the new technology was less costly.

Breast cancer is the leading cause of cancer death in women 40 to 55 years old. Approximately 175,000 new cases of breast cancer were diagnosed in the United States in 1999, and 43,700 deaths were expected from the disease.¹⁻³ Mortality from breast cancer declined between 1989 and 1992 for all women between 30 and 79 years of age, and this decline was related to early detection of the disease.⁴

Early detection was achieved by the increase in screening mammography programs and breast self-examination. These methods increased the number of breast abnormalities found and concomitantly increased the number of diagnostic procedures.^{5,6} Presently, more than 1.2 million breast biopsies are performed annually in the United States.⁵

A number of new technologies are used currently to diagnose nonpalpable, radiographically suspicious breast abnormalities. The key question in determining use of any technology is its effectiveness. Once effectiveness has been determined, one of the next questions is: "How much does it cost?"

The major biopsy alternatives currently available for nonpalpable abnormalities include needle-wire-

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localized open surgical biopsy (OSB), stereotactic core needle biopsy, and directional vacuum-assisted biopsy (VAB). Fine needle aspiration biopsy has several noted limitations that reduce its effectiveness as a diagnostic tool, so is not evaluated in this study.⁷⁻¹³

According to the literature, VAB is superior to stereotactic core needle biopsy for nonpalpable masses due to better harvesting, less time for the procedure, fewer complications, and a higher success rate for certain specimen types.^{5,12-19} VAB has equivalent effectiveness to OSB, which is the current accepted gold standard for histologic diagnosis of breast cancers.^{5,11,16-18}

The costs of stereotactic core needle biopsy and OSB have been investigated, and stereotactic core needle biopsy has been shown to be less costly than OSB.²⁰⁻²⁶ Most of these studies are from a payer perspective and analyze allowed charges or model costs in terms of allowed charges. One study included VAB cases in the analysis, but no literature exists to date only on the comparative costs of the VAB and OSB procedures.

Additionally, no literature exists that compares the cost from the provider (facility) perspective and includes variable and fixed (ie, overhead) costs. Burkhardt and Sunshine support the belief that resource costs are the most accurate and best measures of cost,²⁴ but agree with others that these are very difficult and expensive to obtain.^{27,28} This is the first of several potential studies that identifies the resource costs of VAB and OSB from the perspective of the facility as provider of the services. Providers must consider the use of new technology to provide better quality care and meet the demands of patients who have more information about these new technologies available through the Internet. Thus, providers must have the information, when it is efficiently available, to compare the cost of the new technology with its benefit in terms of freed resources that can be utilized for other patient care.

... MATERIALS AND METHODS ...

The vector of steps and associated services used to identify women for diagnostic workup of nonpalpable breast abnormalities was developed through the current literature and clinically reviewed by physicians.^{29,30}

Primary data collection by observation was used to identify resources (eg, labor, equipment, supplies, facility room time) used in both the VAB and OSB procedures. Identification and enumeration of actu-

al resources were important to compare costs of the 2 procedures from the facility perspective. Valuation of the resources was by imputation from published literature due to the difficulty of obtaining proprietary information from the facilities and the generalizability of results.

All overhead costs were treated as fixed costs in this study, which is a short run perspective.³¹ This assumption allows facility decision-makers to make practical use of the data. Additionally, overhead costs were analyzed because the use of the new VAB procedure was expected to impact those costs, and they provide a measure of the opportunity cost of the procedures.

The production function for VAB and OSB procedures was segmented into 2 areas: (1) administrative procedures common to both (eg, registration, admission, discharge and intake procedures) and (2) procedures specific to the technical process of performing the breast biopsy (eg, positioning of patient, room setup, patient instructions).

Site Selection

The time over which the facility provided the biopsy procedure and the monthly volume of procedures by physicians were the main criteria for inclusion in the study. OSB had been performed for more than a decade, and proficiency in that procedure was assumed for physicians practicing in a facility with a minimum of 15 to 20 procedures per month.

We wanted VAB sites and physicians with experience comparable to that of the OSB sites and physicians for comparison. The intent was to measure resource variation and associated costs related to the process of care and patient attributes (eg, age, diagnosis) and not variation related to inexperience with the relatively new VAB procedure. Inclusion criteria for facilities and physicians in the study for VAB procedures were a minimum of 24 months providing the VAB procedure and a minimum of 15 to 20 procedures per month.

The time and expense of costing resources limited the number of facilities to study. The inclusion criteria coupled with the requirement that sites for multiple physicians and patient observations must provide both VAB and OSB procedures further constrained potential study sites. This last requirement controlled for intrafacility differences between the VAB and OSB procedures.

A total of 11 sites participated in the study. Two sites that met the inclusion criteria agreed to allow the trained observers to conduct time-and-motion studies, staff interviews, and patient record reviews

for the study. A third site that did only OSB was chosen for comparison of resource utilization for that procedure. Additionally, we used 8 other sites covering 7 states (3 midwestern, 2 southeastern, 1 mountain, 1 western) in which the VAB resources were directly observed for 1 or 2 physicians over several procedures. VAB was a relatively new procedure, and we wanted to measure variation in resource use across facilities and physicians. These sites met the same proficiency requirements for time and volume as the others to ensure comparable physician experience with the procedure. The inclusion of other VAB sites allowed for variation due to patient needs (warranted variation) and supply-driven practice variation (unwarranted variation).

Physicians at the sites were a convenience sample based on scheduled procedures during the days of observation. Patients were selected for the procedures based on clinical appropriateness and the decision as to which biopsy procedure to undergo after private discussion with their physicians.

Table 1 indicates the sites, facility types, procedures, and number of patients observed.

Resource Identification

Labor. Both procedures were directly observed by trained research staff to confirm the process of care previously defined by the clinicians. All steps in the process of care were identified and in the analysis were grouped according to administrative or technical procedure steps.

Administrative steps are common to both VAB and OSB and are not part of the technical breast biopsy procedures. The research staff observed several of both procedures to identify and measure the administrative steps. Administrative support, housekeeping, and clinical staffs were interviewed to determine their recall of the time to complete the steps. There was little difference between the observed and reported time within a facility. Registration, admission, and cleanup activities are fairly standard across all patients within a facility. Additional time and effort were not spent collecting data on these steps ancillary to the technical procedures. The average time derived from the

observed and self-reported times within a facility was used across all patients in the facility.

The administrative steps of the biopsy procedures were analyzed separately from the technical biopsy steps because they are necessary steps in patient care, but we did not want variation related to efficiency or inefficiency of these steps to be attributed to the technical procedures. We wanted to evaluate these steps, as there may be differences in resources and intensity of use associated with the different procedures.

The administrative steps were as follows:

- Pre-op call—call by facility staff and/or physician office staff to remind patient of pre-op instructions;
- Registration—collection of administrative information on date of procedure;
- Admission—collection of clinical data on admission to treatment unit; and
- Postprocedure call—facility or physician office call to check on patient after return to home.

Observation of the technical steps was done for all cases. Medical records were reviewed after the procedures to check the type of professional staff involved in procedures (eg, interventional radiologist, surgeon, radiographic or operating room technician, nurse, anesthesiologist, certified registered nurse anesthetist) and lists of supplies and equipment used. Information such as anesthesia type, supplies, and number of films taken was abstracted from the record, as that recorded information was considered more accurate.

Table 1. Number of Observations for VAB and OSB by Site and Facility Type

Site	VAB			OSB		Total
	Imaging Center	ASC	Hospital	ASC	Hospital	
1	0	30	0	0	26	56
2*	12	6	15	0	0	33
3	0	30	0	28	0	58
4	3	0	0	0	17	20
Total	15	66	15	28	43	167

ASC = ambulatory surgery center; OSB = wire-localized open surgical biopsy; VAB = vacuum-assisted biopsy.

*Site 2 is an aggregate of the 8 sites in 7 states with VAB procedures only.

The technical biopsy steps were as follows:

- Radiology room setup and cleanup (OSB)—preparing room and equipment for procedure;
- Wire localization (OSB)—patient preparation, wire insertion, and films required in process;
- Procedure room setup (operating room or procedure room as appropriate for each procedure)—preparing room and equipment for procedure;
- Patient preparation—patient drape, intravenous line start (OSB), anesthesia start;
- Biopsy (OSB and VAB)—operative site preparation, incision, biopsy;
- Patient and room cleanup (OSB and VAB)—closure and bandaging of site, room cleanup, preparation of specimen for radiographs when appropriate, patient instructions (VAB); and
- Recovery room (OSB)—recovery from anesthesia and patient instructions.

Supplies and Equipment. Disposable supplies and equipment used in the VAB and OSB procedures were identified through a combination of observation by research staff, sterile tray packing lists at facilities, and confirmation with the medical and billing records. Information from these sources was compared and combined to develop an all-inclusive list of supplies for each procedure. The list of supplies was compared with information published in Milliman and Robertson.³²

The VAB procedure required the stereotactic table and Mammotome driver. The OSB used a mammography unit, stereotactic table, or ultrasound for wire localization.

Valuation of Resources: Costs

Costs were divided into variable and fixed (overhead). Variable costs are associated with the resources of labor, supplies, and procedure-dedicated equipment. They are the sum of the products of the vectors of resources used for the procedure and their associated unit costs. Fixed (overhead) costs included all expenses beyond the labor, supply, and dedicated-equipment cost (ie, rent, utilities, maintenance, administration).

Labor. The physician professional component (including anesthesiologists) of the cost was not included in the variable cost calculation. At some sites, physicians were employed by the facility and salaried. Their services were billed separately from the facility costs, so these costs were excluded from the analysis. Salaried physician and nurse anesthetist cost to the facility was treated as a transfer cost due to the revenue from the professional bill covering the salary, benefits, and fringe expenses.

A per minute cost (salary and benefits) for the ancillary professionals and administrative support and housekeeping staffs was derived from US national average salaries for each of these labor resources.³³⁻³⁵ These derived costs were multiplied by the actual or imputed time spent for each of the patient care steps in the administrative and technical steps of the biopsy procedures.

Supplies. Price lists for disposable supplies and equipment were obtained from a number of study sites. The costs varied considerably across facility types and geographic areas. This was due to market power for discounts and other reasons. Standard unit costs for supplies were used for generalizability of results. These were derived from Milliman and Robertson and the manufacturer's price list (for Mammotome supplies).³²

Equipment. Dedicated equipment (ie, equipment used only for a specific procedure such as the Mammotome driver for VAB) was treated as a variable cost in this study. The capital expenditure for the Mammotome driver and maintenance contract was derived from actual records, as well as the manufacturers' prices. Following standard industry depreciation guidelines for medical equipment, the cost of the driver was depreciated over the 5-year life of the equipment, and the equipment cost per procedure was amortized by dividing the depreciation cost by the average number of annual procedures per facility.

The number of annual procedures was based on the numbers from the facilities under study, which are high-volume facilities. A sensitivity analysis was planned to determine the effect of volume on cost.

The stereotactic table was a capital expense. It is used for stereotactic core needle biopsy and needle-wire localization in OSB, as well as VAB. It was not considered dedicated equipment for the VAB procedure because of its use across the various procedures. The cost was depreciated according to standard industry guidelines for medical equipment over the 5-year life of the table, and the cost per procedure was amortized by dividing the depreciation cost by the average number of annual procedures per facility. The average annual number of procedures used in the depreciation was the same for all the VAB procedure sites, and all overhead cost was apportioned to the VAB procedure, as it was difficult to prorate this cost for the OSB. This will provide some overestimate of the fixed cost for VAB compared with OSB.

For the OSB procedure, capital allocations were included in the overhead costs of a surgical suite in

an ambulatory surgery center (ASC) or a hospital and were not separated from other overhead costs. The overhead cost for the mammography unit and room was not included in the fixed costs for OSB. The use of these for needle-wire localization incidental to OSB took a very small percentage of time compared with their intended use for screening and diagnostic mammograms. The facilities studied did not separate the cost for screening and needle-wire localization when making overhead calculations. Not doing this provided some underestimation of the fixed costs for OSB.

Overhead. Overhead expenses for each facility type were calculated on a per procedure basis to measure the administrative and general support costs that are required to run an ASC, hospital outpatient department, or imaging center. For freestanding ASCs, overhead cost figures were calculated on a per minute basis from a national industry survey.³²

Overhead costs detailed as needed for this study were not available from the hospital study sites for proprietary reasons. Published sources were reviewed that would provide generalizability of the results. California institutional cost reports were

Table 2. Total VAB and OSB Procedure Costs

Type of Cost	VAB (\$)						OSB (\$)			
	Imaging Center		ASC		Hospital*		ASC		Hospital†	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Variable costs										
Labor‡	29.89	12.98	35.20	13.98	37.01	14.44	80.66	13.26	81.21	18.78
Support staff (radiation technician or nursing)										
Housekeeping							5.01§		2.72	1.14
Subtotal labor	29.89		35.20		37.01		85.67		83.93	
Supplies										
Anesthesia	3.29		1.26	1.19	0.89		129.42	55.70	139.17	50.34
Imaging							27.02	5.00	27.02	5.00
Medical/surgical	270.08	4.87	256.91	39.83	268.82		139.18		139.18	
Subtotal supplies	273.37		258.17		269.71		295.62		305.37	
Equipment (Mammotome driver)	6.19		6.19		6.19					
Subtotal variable costs	309.45		299.57		312.91		381.29		389.30	
Fixed costs										
Administration/overhead	81.93¶		337.37	74.56	416.00	146.90	787.20¶¶		971.00¶¶	
Equipment (table)	125.82		125.82		125.82					
Subtotal fixed costs	207.75		463.19		541.82		787.20		971.00	
Total procedure costs	517.20	17.85	762.76	129.56	854.73	161.34	1168.49	88.96	1360.30	75.26

ASC = ambulatory surgery center; OSB = needle-wire-localized open surgical biopsy; VAB = vacuum-assisted biopsy.

*Radiology department or outpatient surgery.

†Outpatient surgery.

‡Costs exclude all physician and certified registered nurse anesthetist labor since they bill and are reimbursed separately from the facility.

§Standard housekeeping time per ASC procedure × labor rate based on initial observations and staff interviews.

||Based on standard pack of supplies used across all procedures in these facilities.

¶Administration/overhead costs consist of all nonclinical labor and supply costs as well as facilities costs allocated on the basis of total procedure time (see Table 4).

used to calculate these fixed costs on a per minute basis for surgical services. These data were published for 19 hospitals in California that included rural, urban, teaching, and nonteaching facilities. An average was derived for these facilities and used.

For imaging centers, variable costs per minute were based on actual financial data from the 1 center participating in the study. Once these per minute rates were calculated for each facility type, per procedure overhead rates were derived by multiplying the per minute overhead rates by the observed duration of each procedure.

... RESULTS ...

Patients

A total of 71 OSB and 96 VAB procedures were studied. There was little difference between the ages of OSB and VAB patients. The mean ages for the respective groups were 54 and 55 years.

Determination of a clinical difference between the patients undergoing VAB and OSB was difficult. The physician and patient made the decision about the type of procedure. An analysis of the mammography diagnoses for the OSB and VAB groups provided little information as a source of potential bias. At 1 facility all patients who had the OSB procedure had a mammography diagnosis of nonpalpable lesion, indeterminate, and 85% of those who underwent the VAB had a diagnosis of microcalcifications.

A review of the pathology diagnoses for the OSB and VAB groups indicated 17% of OSB and 10% of VAB patients had a diagnosis of cancer. There was no difference between mammography diagnoses for the subgroups of VAB and OSB patients diagnosed with cancer. There was no difference between sur-

geon time for either the VAB or OSB procedures for those patients with a diagnosis of malignancy compared with all others without malignancy.

Total Costs

The total facility costs (fixed and variable) of the VAB procedure compared with the OSB procedure were lower (Table 2). The ASC cost comparison of the VAB and OSB procedures was \$763 versus \$1168.

The overall cost advantage for using VAB ranged from \$314 (27% savings) to \$843 (62% savings) per procedure depending on the facility type (Table 3). Facility type and procedure duration influenced cost the most.

Variable Cost (Labor, Supply, and Equipment Costs)

The wire localization component of the OSB involved significant radiology staff time and resources. The procedure usually was done in a radiology department with proximity to the hospital or ASC surgical suite and involved both a radiologist and technician. Standard mammography equipment was used to place the wire, which does not require additional capital expenditure. In some facilities, wire placement was done using a stereotactic table. The wire localization variable cost incurred approximately 60 minutes of technician time for a cost of \$25. The supply cost (based on standard list of supplies used) was \$27 (including film, wire, and miscellaneous supplies).

The anesthesiology variable cost included all drugs and supplies used in administering anesthesia. In the VAB procedure, the radiologist or surgeon administered a local anesthesia (lidocaine with epinephrine) to the biopsy site. The decision to use local, monitored anesthesia care or general anesthesia in the OSB was based on the preference of the physician and patient. General anesthesia included a monitored anesthesia care setup with an endotracheal tube and also the gasses (eg, oxygen, nitrous oxide, isoflurane). Use of general anesthesia in the OSB increased the cost of that procedure. OSB can be done with local anesthesia, but only 1 patient had local anesthesia.

The VAB was performed using the Mammotome Breast Biopsy System™ (Ethicon Endo-Surgery, Cincinnati, Ohio) and the MicroMark Clip™ (Ethicon Endo-Surgery, Cincinnati, Ohio), the Mammotest

Table 3. Cost Advantage of VAB Compared With OSB by Facility Type

OSB Facility Type	VAB Facility Type					
	Imaging Center		ASC		Hospital	
	\$	%	\$	%	\$	%
Hospital	843.10	62	597.54	44	505.57	37
ASC	651.29	56	405.73	35	313.76	27

ASC = ambulatory surgery center; OSB = needle-wire-localized open surgical biopsy; VAB = vacuum-assisted biopsy.

Plus (Fischer Imaging, Denver, Colorado), or the Lorad StereoGuide (Lorad, Danbury, Connecticut) stereotactic table.

Return on investment for the equipment, including the stereotactic table, is not realized unless a facility does more than 100 procedures a year. Additionally, proficiency with the procedure and the resulting quality of care provided are volume dependent.

The disposable probe and clip used in the VAB impacted that procedure's cost. Use of some supplies varied within a procedure, such as use of the marker clip in the VAB (average clip utilization was 71%). The supply costs of the VAB were slightly less than those of the OSB (maximum difference of \$47.20). A significant portion of the VAB supply cost was the disposable probe and clip, and the major cost driver for the OSB procedure was the anesthesia.

When only variable costs were compared, the difference between the facility type with the highest-cost procedure (hospital) for the OSB and the facility type with the lowest-cost procedure (ASC) of the VAB was only \$89.73 (\$389.30 - \$299.57).

Fixed Cost (Overhead)

OSB patients were usually treated in more costly facility types, and the patients underwent a much longer procedure. On average, VAB procedures took 75 minutes compared with 175 minutes for the OSB procedures (including wire localization and recovery time). One of the major factors related to the lower cost of the VAB was facility type. The VAB was performed at facility types associated with lower overhead expenses (Table 4).

There was significant economic value because of lower overhead costs with the VAB compared with the OSB procedure. The per procedure overhead expenses for VAB were \$208, \$463, and \$542 in an imaging center, freestanding ASC, and hospital-based ASC, respectively. This overhead was substantially lower than the OSB overhead of \$787 and \$971 in a freestanding ASC and a hospital-based surgery center, respectively.

The average capital expense per procedure for both the table and driver, including maintenance, for the VAB was \$132. The average purchase cost for the stereotactic table was \$225,000, the cost of the driver was \$10,000, and annual maintenance on both was \$17,000. As previously indicated, the cost of the table and maintenance were assigned to the VAB

procedure. It was not possible to prorate the overhead between VAB and OSB even though some facilities used a stereotactic table for wire localization. The assignment of all cost to VAB for the equipment and maintenance contract resulted in an overestimate of the overhead for that procedure.

Fixed cost for the wire localization in the hospital setting was not included in the analysis, as facilities did not divide the department overhead for screening mammography use versus localization. Therefore, the result was an underestimate of the actual hospital overhead for OSB.

Sensitivity Analysis

The VAB was a lower-cost procedure than the OSB, but practice variation affected the results for both procedures. A sensitivity analysis was done to determine the effect of important assumptions and variables on the result (Figures 1 and 2).

Procedure duration was a major factor affecting the cost difference between VAB and OSB. VAB procedures saved slightly over 1.5 hours of staff time and facility resources. A 20% increase in VAB procedure time to 90 minutes added less than \$100 to the procedure cost.

The average rate of clip use in the VAB procedure was 71%. Increasing that by almost 30% added less than \$40 to the average cost of the VAB procedure.

The assumption of 485 VAB procedures performed annually was considered "high volume" at the facilities included in the study. This averaged to fewer than 2 procedures per day annually (5 days per week, 52 weeks per year). With an increase in the time for the VAB to 80 minutes and an 8-hour day, 100% utilization for the stereotactic table and driver would allow 6 procedures per day (1560 procedures annually). An increase in the number of

Table 4. Fixed Cost per Minute by Facility Type

Procedure	Fixed Cost and Procedure Average Time					
	Imaging Center		ASC		Hospital	
	\$	Min	\$	Min	\$	Min
VAB	1.09	75	4.50	75	5.55	75
OSB	NA	NA	4.50	175	5.55	175

ASC = ambulatory surgery center; NA = not applicable; OSB = needle-wire-localized open surgical biopsy; VAB = vacuum-assisted biopsy.

Figure 1. Sensitivity Analysis for the Vacuum-Assisted Biopsy in a Freestanding Ambulatory Surgery Center

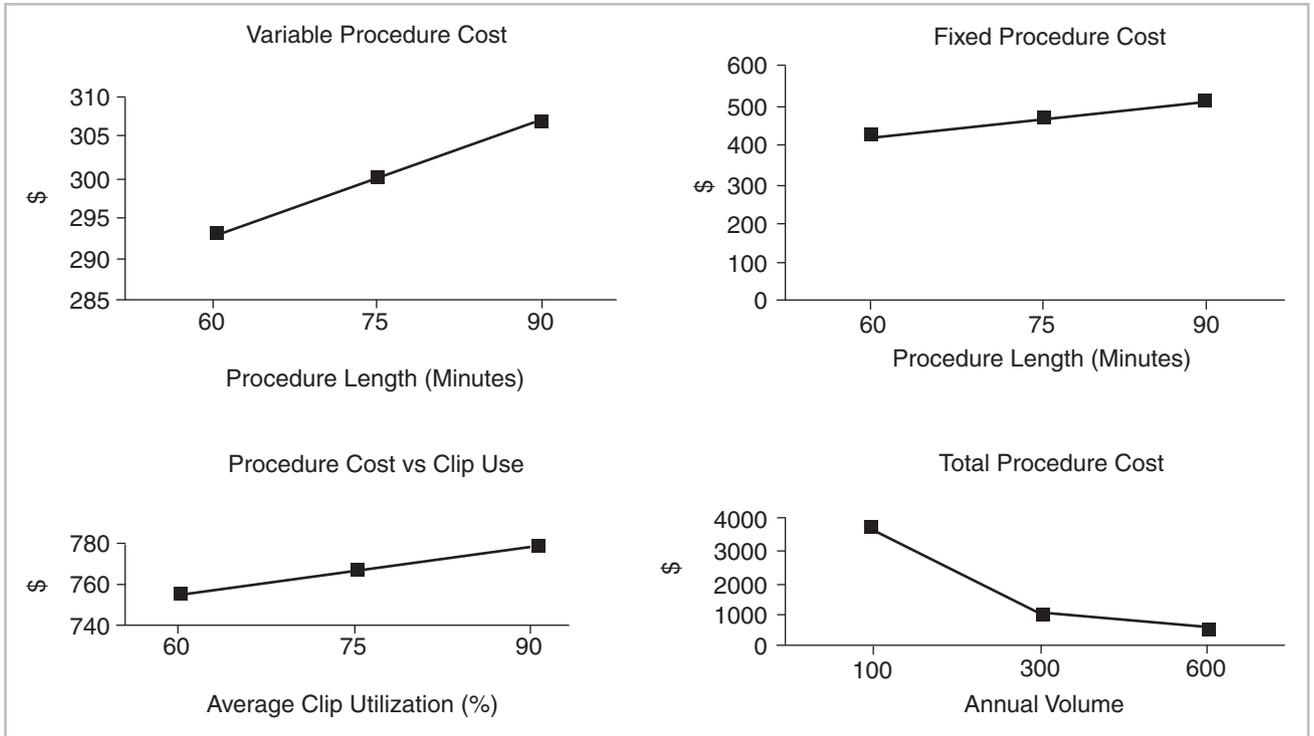
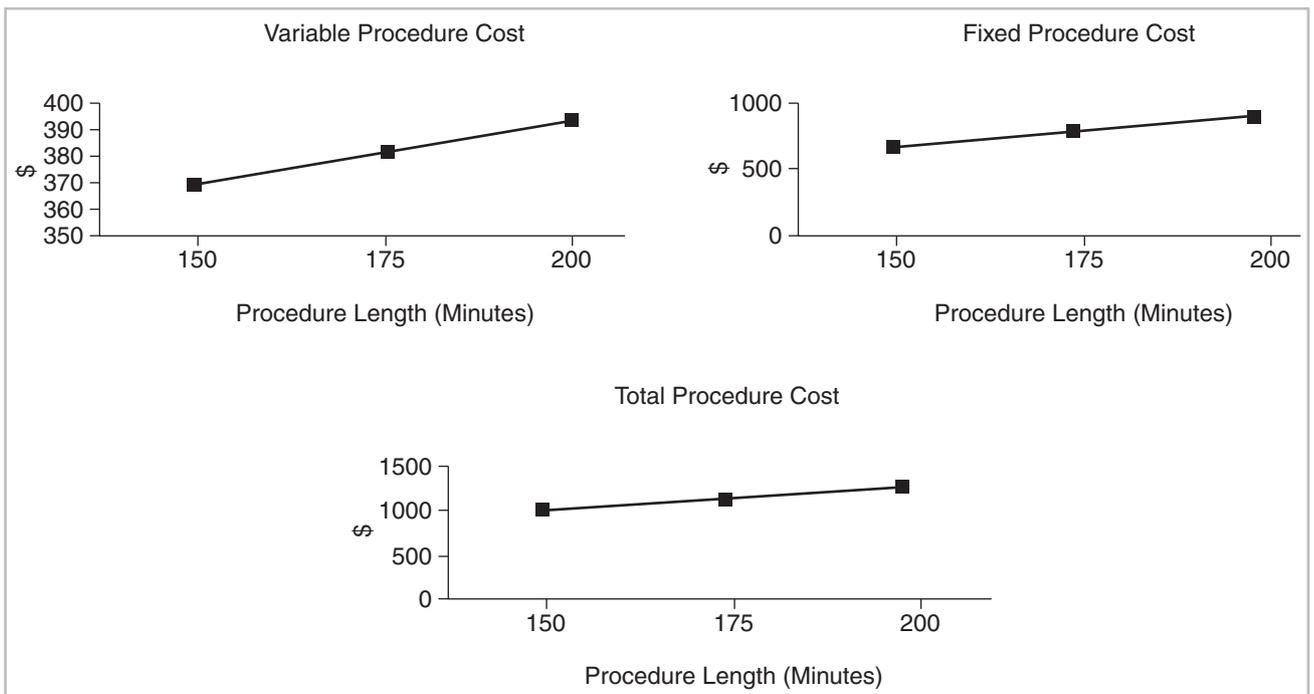


Figure 2. Sensitivity Analysis for the Wire-Localized Open Surgical Biopsy in a Freestanding Ambulatory Surgery Center



procedures, which is very plausible assuming the analysis was based on only 31% of capacity, would greatly decrease the cost of the overhead for capital equipment per procedure.

Total average cost per procedure is more sensitive to changes in volume (number of annual procedures at a facility) than variation in the amount of time it takes to complete the technical procedure. As an example, a worst case scenario was developed and analyzed for VAB and compared with a best case scenario for OSB in both the ASC and hospital sites of care. We identified the cases with the longest time for the VAB procedure in the ASC and hospital and recalculated variable labor costs for them. We recalculated the labor costs for the cases with the shortest time for the OSB procedures in the ASC and hospital. Next, the volume of annual VAB cases was decreased by 50% (ie, to 15% of capacity), and the variable equipment cost (Mammotome driver) and overhead costs were recalculated. The VAB average annual costs in the ASC and hospital settings were then compared with the OSB costs (as in Table 2). The VAB cost under the worst case assumptions increased to \$967 in the ASC and \$1024 in the hospital. The OSB cost under the best case assumptions decreased in the ASC to \$1137 and \$1331 in the hospital.

The total cost of the VAB was lower than that of the OSB procedure even under assumptions that increased the cost of the VAB.

... DISCUSSION ...

It was the intent of the study to quantify what practice variation presently exists within the VAB and OSB procedures and attribute a cost to it so that comparisons can be made between the 2 procedures. The process of identification of biopsy procedure steps and facility resources used was time consuming and expensive. There was an obvious trade-off between the inclusion of many sites in the study with more generalizability and unreasonable study cost and fewer study sites with less generalizability but more reasonable study cost. We chose the latter and realize there are limitations due to the small number of facilities, small number of physicians, and limited geographic sites. This was a convenience sample, and with all convenience samples there is a potential for patient selection bias regarding procedures that could differentially affect the results. Available demographic and clinical data

were analyzed to estimate potential bias from these sources. It was not known what else might influence the physician decision to recommend a particular procedure for a specific patient, but biased results due to differential selection based on age and diagnosis were not evident from the analysis of the demographic and clinical variables.

We thought that some information is better than no information when making decisions about the use of a new technology. Further, we realize that facility and physician efficiencies and inefficiencies will always require any results to be interpreted with the facility substituting its experience and associated costs for those identified in this analysis.

Facility differences related to brands of disposable supplies, quantities, and whether the supplies were prepackaged or facility bundled into sterile surgical packs affected cost. Additionally, some physician practice variations affected types of resources, quantity, and time. Some physicians who performed the VAB procedure did so with the assistance of a single radiology technician, and others used 2 technicians. On average, the technician time used per VAB procedures was less when 1 technician assisted (22-minute difference).

Some facilities used administrative staff for patient registration and preoperative calls, and others used radiology technicians. The time difference was almost twice as much for the technicians, and it is not known whether there was any difference in patient satisfaction or time related to the procedure as a result. The time-and-motion studies indicated a potential for additional efficiencies in both the VAB and OSB procedures, and this should be studied further. It was beyond the scope of this research project.

The number of different geographic locations captures the practice variations in these data. A large number of procedures were not observed at some locations. All locations were identified as high-volume sites with physicians proficient in the procedures. The variation present in these data and reflected in the results is variation associated with "mature" practice. These results may not reflect the cost of providers inexperienced with the VAB procedure.

When available, costs from national data sources were used. These published data have limitations in that they are at least a year out of date. They do provide for more generalizability on resource costs as they smooth the market power influence

of large, high-volume healthcare facilities that can negotiate discounts on supplies and other items.

Overhead costs were from a source with limited generalizability: California. The derived per minute overhead department cost was compared with the cost provided by 1 participating facility in the Midwest. There was little difference between the 2 costs. This information is very difficult to obtain due to its proprietary nature.

The average savings per procedure would be greater as the volume of procedures increased. The assumption of 485 procedures annually used in this study was only 31% of capacity (using the definition of full capacity developed by Burkhardt and Sunshine²⁴).

The VAB procedure may not be appropriate for all facilities because of the major cost associated with the purchase or lease of a stereotactic table. The volume of procedures needs to be sufficient to attain, at the minimum, cost neutrality. That volume would be some number fewer than 2 procedures per day according to this study. However, alternatives to the stereotactic table, such as using a \$50,000 ultrasound machine for image guidance, can reduce the cost of VAB more.

The opportunity costs that accrue for the facility from the VAB procedure (eg, operating room time,

recovery room space, radiology suite availability where the wire localization occurs, and employed staff time) allow for scheduling of other, more intensive surgical procedures. Unless the facility operates at capacity, in which case more space, more personnel, and more utilities would be necessary to expand services, overhead costs savings would be lower when switching from the OSB to the VAB procedure *in the same facility*. The fixed cost savings per procedure for changing to VAB from OSB in the hospital are \$429 (Table 2). On the other hand, those healthcare institutions in need of additional capacity and with the ability to designate in which facility type the procedure is done (eg, hospital operating room suite vs ASC) can reduce overhead costs by directing the least costly procedure to the lowest-cost facility type. Fixed cost savings per procedure when switching from OSB in a hospital to VAB in an ASC are approximately \$508 (Table 2).

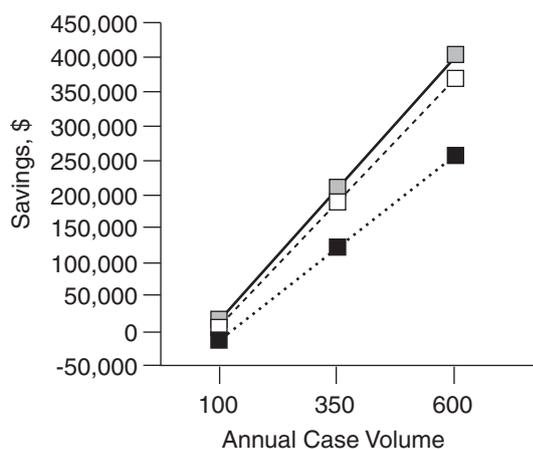
Figure 3 provides information for facilities to assess the benefit of converting breast biopsy procedures from OSB to VAB. The cost differences between the 2 procedures allow healthcare administrators to find hundreds of thousands in annual costs savings, depending on their volume of cases. Those savings opportunities would increase if the provider were to move from OSB to VAB in a lower-cost setting.

Facility administrators can directly influence the site of care for breast biopsy by creating an environment that supports a new procedure such as VAB (eg, in an outpatient women's health or breast care center). Administrators can align physician incentives so that they prefer to perform a breast biopsy in a procedure room or imaging room environment that is conducive to their schedule and provides high-quality patient care.

Surgeons also can choose the environment in which they perform breast biopsy. Presently their choices include their own office, an outpatient operating room, an outpatient procedure room, and the hospital imaging department. Ultimately the physician's choice of the site of care is based on the availability of a specific hospital site, the physician's privileges with the hospital, and patient scheduling.

Finally, managed care executives also can influence the site of care by adopting patient care guidelines or clinical pathways for breast biopsy that include VAB. Managed care organizations can align contractual and economic incentives with physicians and hospitals that will encourage a minimally invasive approach to breast biopsy whenever possible. Examples include creating supply carve-outs for

Figure 3. Facility Cost Savings Opportunity



Shaded squares represent the cost savings realized by converting from ambulatory surgery center (ASC) needle-wire-localized open surgical biopsy (OSB) to imaging center vacuum-assisted biopsy (VAB); open squares, the savings realized by converting from hospital OSB to ASC VAB; and solid squares, the savings realized by converting from ASC OSB to ASC VAB.

high-cost disposable items so physicians can perform VAB in their office.

The study found that the VAB is a lower-cost procedure, but physicians may recommend a second biopsy using the OSB for patients with atypical hyperplasia or discordant pathology and mammography results. Some physicians send all patients with abnormal histology for an OSB, which, depending on the margins of the surgical specimen, could be a second biopsy or a definitive treatment. Therefore, the cost of biopsies for VAB patients who undergo a subsequent OSB biopsy should be considered.

The "miss rate" with VAB is reported to range from 0%^{16,17,36,37} to 17%.^{5,36} OSB miss rates, on the other hand, are reported to be as high as 22%.¹³ Using the highest miss rates for VAB and OSB procedures (17% and 22%, respectively) and adding the cost of the repeat procedure to both yields an average cost of \$961 for VAB and \$1426 for OSB in an ASC. The potential savings increase to \$464 in favor of VAB when the miss rate is considered.

Although not quantified in this study, there are broader facility cost advantages associated with switching from the OSB to the VAB procedure. In a busy operating room, conversion from OSB to VAB may reduce staff overtime. Additionally, capacity could be increased because of the provider time difference attracting more physicians. Other benefits associated with use of VAB versus OSB may include the reduction of morbidity and mortality generally associated with any operative procedure such as postoperative infection and general anesthesia-related complications.

An interesting finding not directly related to procedure cost was the patient time associated with the procedures. The total time the patient was at the facility for the VAB was 90 minutes (procedure time plus waiting time). For the OSB patient, total admit-to-discharge time ranged from 250 to 416 minutes (an average of 250 minutes for the cases in the study).

The variability in the OSB times for the patient is due to scheduling the wire-localization procedure long before the surgical procedure. The OSB patient encounters many more caregivers in the hospital or ASC and must travel around the facility, from the needle-localization insertion to the surgery and finally to recovery. On average, the OSB patient encounters 8 caregivers compared with 4 for the VAB patient.

Also not quantified in the study are the cost and quality-of-life issues from the patient's perspective, which may be appropriate subjects for a follow-up study. There is increased patient satisfaction due to

significantly less time and cost (lost time from work and fewer preoperative tests) involved with the VAB procedure with no sacrifice in effectiveness, less chance of surgical complications, significantly less recovery time, and better cosmetic results.

... CONCLUSION ...

The total labor and supply cost difference between VAB and OSB may be small, but the consideration of other cost savings such as to the patient, the payer, and to society as a whole may support adoption of the VAB technology. VAB appears to provide small absolute variable cost savings to the facility, but much greater savings when considering total costs to all involved.

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